# Sheet (4)

## Induction Motor (I.M)

$P_{out} = 40hp$, 3300V, 50HZ, 4 poles, 3-ph star connected induction motor, slip = 2%. P.f = 0.8 lag at full load. Stator copper losses, core losses and mechanical losses are:
1000 w, 1500 w, 1200 w

(1 hp = 746 w). Find at full load:
(1) motor speed (2) The line current (3) rotor copper loss
(4) $\eta$%

الحل :-

$\because N_s = \frac{120 f}{P} = \frac{120 \times 50}{4} = 1500 \; rpm$

$\because$ slip = 2% $\therefore 0.02 = \frac{N_s - N}{N_s}$ or $N = N_s(1-S)$

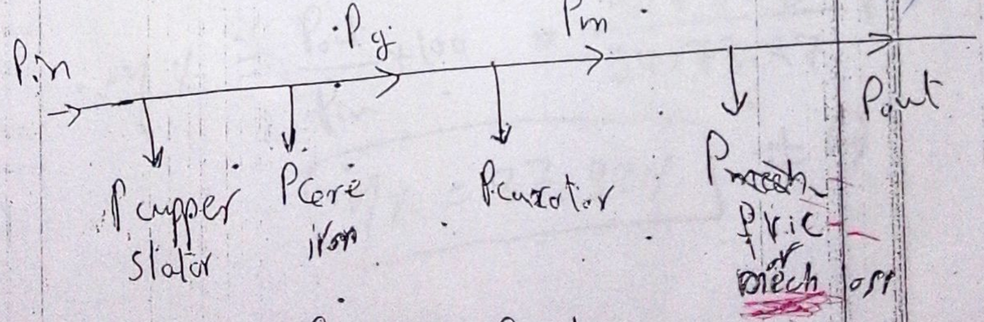
$\therefore 0.02 \times 1500 = 1500 - N$

$\therefore \boxed{N = 1470 \; rpm}$ # (1)

$N = N_s(1-S)$

$\because P_{in} = 3 V_1 I_1 \, P.f$

والمطلوب إيجاد $I_1$ .: لابد من حساب $P_{in}$ أولا
عبر مخطط القدرة




$\therefore P_m = P_{mech} + P_{out}$

$\therefore P_m = 1200 + (40 \times 746) = 31040 \, w$

$P_g : P_{cu2} : P_m$
rotor
$1 : S : 1-S$

$\therefore P_g(1-S) = P_m \quad \therefore P_g = \dfrac{P_m}{1-S}$

$\therefore P_g = \dfrac{31040}{1-0.02} = 31673.47\ W$

$\because P_{in} = [P_{coppers\ stator} + P_{core}] + P_g$

$\therefore P_{in} = [1000 + 1500] + 31673.47$

$\therefore P_{in} = 34173.47\ W$

$\sqrt{3}\, V_1 I_1 P.f \Leftarrow \because P_{in} = 3 V_1 I_1 P.f_1$

$\therefore 34173.47 = 3 * \dfrac{3300}{\sqrt{3}} * I_1 * 0.8$

$\boxed{\therefore I_1 = 7.4735\ A}$ # ②

لابد من جعل الجهد المعطى
جهد phase لأنه يعطيه
في توصيلة star ضرورى
المسألة دائما line

$\therefore P_{cu2} = S \cdot P_g$

$\therefore P_{cu2} = 0.02 * 31673.47 = \boxed{633.47\ W}$ # ③

$\therefore \eta\% = \dfrac{P_{out}}{P_{in}} * 100 = \dfrac{40 * 746}{34173.47} * 100$

$\boxed{\therefore \eta\% = 87.32\%}$ # ④

$P_m$ , $R$. , $I_a = 20A$

3-ph, 500 V, 50 HZ, 6 poles, star connected I.M develops (net o/p = 20 hp) at 950 rpm with P.f = 0.85 lag, $P_{mech.} = 1$ hp [illegible] stator losses are 1500 W (neglect core losses). Find:

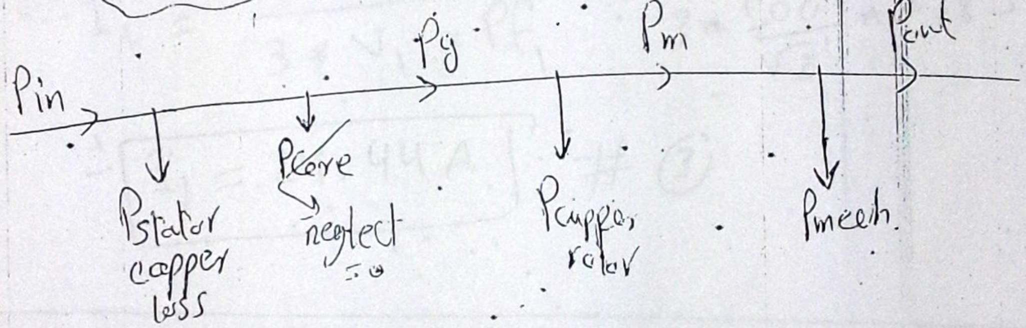
① slip ② rotor copper losses ③ line current

- الحل -

$\because N_s = \frac{120 f}{P} = \frac{120 * 50}{6} = 1000$ rpm

$\because N = 950$ rpm $\therefore S = \frac{N_S - N}{N_S} = 0.05$

$\therefore S = 5\%$ # ①




$\because P_m = P_{mech.} + P_{out} = (1 * 746) + (20 * 746)$

$\therefore P_m = 15666$ W

$\because P_g : P_{cu2\,rotor} : P_m$

$1 : S : 1 - S$

$\therefore P_{cu2} * (1 - S) = S * P_m$

$\therefore P_{cu2} = P_m \frac{S}{1 - S} = 15666 * \left(\frac{0.05}{1 - 0.05}\right)$

$\therefore \boxed{P_{cu2} = 824.526 \text{ W}}$ # ②

$P_{in} = P_{stator\ losses} + P_g$

$\therefore P_g (1 - S) = P_m \qquad \therefore P_g = \frac{P_m}{1-S}$

$\therefore P_g = \frac{15666}{1 - 0.05} = 16490.526\ W$

$\therefore P_{in} = 1500 + 16490.526 = 17990.526\ W$

$\because P_{in} = 3 V_1 I_1 \ Pf_1$

$\therefore I_1 = \frac{P_{in}}{3 * V_1 * Pf_1} = \frac{17990.526}{3 * \frac{500}{\sqrt{3}} * 0.85}$

$\therefore \boxed{I_1 = 24.44\ A}$ # 3

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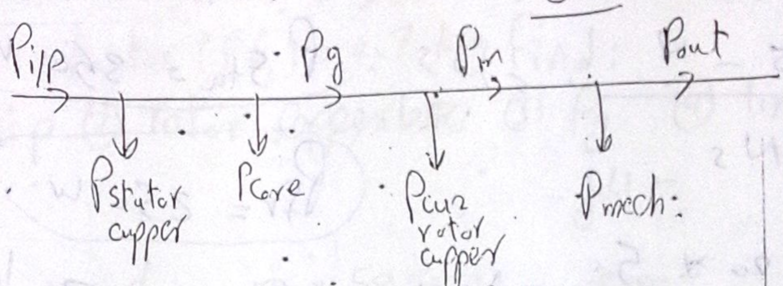
3-ph, 50Hz, 80hp, 4 pole, star connected I.M has $\eta\% =$ ... core losses = 1500W, stator copper losses = 2000W, rotor copper losses = 1400W. find:

① i/p Power ($P_{in}$) ② Airgab Power ($P_g$) ③ shaft speed (N)

الحل




$\because P_{out} = 80 * 746 = 59.680$ W.

$\because \eta\% = 0.9 = \frac{P_{out}}{P_{in}} \quad \therefore P_{in} = \frac{59680}{0.9} = \boxed{66311.11 \text{ W}}$ # ①

$\because P_{i/p} = [P_{stator\ copper} + P_{core}] + P_g$

$\therefore 66311.11 = [2000 + 1500] + P_g$

$\therefore \boxed{P_g = 62811.11 \text{ W}}$ # ②

$\because P_g : P_{cu2\ rotor} : P_m$

$1 : S : 1-S$

$\therefore P_g * S = P_{cu2\ rotor}$

$\therefore S = \frac{P_{cu2\ rotor}}{P_g} = \frac{1400}{62811.11} = 0.02$

$\therefore$ slip = 2%

$\because N_s = \frac{120f}{P} = \frac{120 * 50}{4} = 1500$ rpm $\qquad \because \frac{N_s - N}{N_s} = \frac{S}{1}$

$\therefore N = N_s(1-S) = 1466.56$ rpm # ③



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3ph, 400V, 50HZ, 6 pole star Connected I.M

مثل المسألة رقم (2) تماماً. ولكن بوجود Core losses = 500W

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) 3ph star Connected, 50 HZ; 6 pole, 380 V I.M running at 950 rpm has net o/p. torque of 25 N.m. If the stator Copper losses and Core losses = 350W, mech. losses = 250 W i/p Power factor ($P.f_1$) = 0.7 lag find:

(1) The slip (2) rotor Copperlosses (3) $P_g$ (4) line Current ($I_L$) (5) $\eta$:

-الحل-

$$\because N_s = \frac{120 f}{P} = \frac{120 * 50}{6} = 1000 \text{ rpm}$$

$$\therefore S = \frac{N_s - N}{N_s} = \frac{1000 - 950}{1000} = \boxed{0.05} \quad \# (1)$$

$$P_{in} \rightarrow \underset{\downarrow P_{stator\,copper}}{} \underset{\downarrow P_{core}}{} \xrightarrow{P_g} \underset{\downarrow P_{cu2\,rotor}}{} \xrightarrow{P_m} \underset{\downarrow P_{mech.}}{} \xrightarrow{} P_{out} = \omega T_{out}$$

$$\because P_{out} = \omega * T_{out} = \frac{2\pi N}{60} * T_{out}$$

$$\therefore P_{out} = \frac{2\pi * 950}{60} * 25 = 2487.1 \text{ W}$$

$$P_m = P_{mech.} + P_{out} = 250 + 2487.1 = 2737.1 \text{ W}$$

$$\because P_g : P_{cu2} : P_m$$
$$1 : S : 1-S \qquad \therefore (1-S) * P_{cu2} = S P_m$$

$$\therefore P_{cu2} = P_m * \frac{S}{1-S} = 2737.1 * \frac{0.05}{1-0.05}$$

$$\therefore \boxed{P_{cu2} = 144.05 \text{ W}} \quad \# (2)$$

5) $P_{out}$

$\therefore P_{cu2} = P_g * S$

$\therefore P_g = \frac{P_{cu2}}{S} = \boxed{2881.151\ W}$ # (3)

$\therefore P_{in} = P_g + [P_{\substack{stator \\ copper}} + P_{core}] = 2881.151 + [350]$

$\therefore P_{in} = 3231.151\ W$

$\therefore P_{in} = \sqrt{3}\, V_1\, I_1\, P.f_1$

$\therefore I_1 = \frac{P_{in}}{\sqrt{3}\, V_1\, P.f_1} = \frac{3231.151}{\sqrt{3} * 380 * 0.7}$

$\therefore \boxed{I_1 = 7.013\ A}$ # (4)

$\therefore \eta\% = \frac{P_{out}}{P_{in}} * 100 = \frac{2487.1}{3231.151} * 100$

$\therefore \boxed{\eta\% = 76.9\%}$ # (5)

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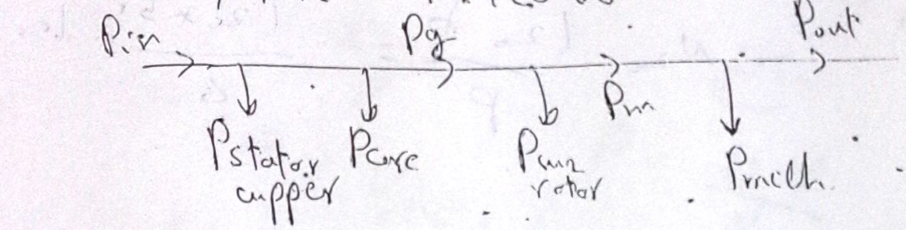
3ph, 20hp, 500V, 50Hz, 6 poles star connected I.M running at 950 rpm with $P.f_1 = 0.85$ lag. mech. losses = 1 hp, Stator Copper losses = 1500W; Core losses = 500W. Find: ① rotor Copper losses ② line Current ($I_1$) ③ $\eta$%.

— sol. —

$P_{out} = 20 * 746 = 14920$ W




$\therefore P_m = P_{mech.} + P_{out} = (1 * 746) + 14920 = 15666$ w.

$\therefore P_g : P_{cu2} : P_m$

$1 : S : 1-S$ $\therefore P_{cu2}(1-S) = P_m * S$

$S = \frac{N_s - N}{N_s}$, $N_s = \frac{120\,f}{P} = \frac{120 * 50}{6} = 1000$ rpm

$\therefore S = 0.05$

$\therefore P_{cu2} = P_m \frac{S}{1-S} = \boxed{824.526 \text{ w.}}$ # ①

$\therefore P_{cu2} = S\, P_g$

$\therefore P_g = \frac{P_{cu2}}{S} = 16490.526$ w

$\therefore P_{in} = [P_{stator\ copper} + P_{core}] + P_g = (1500 + 500) + 16490.526$

$\therefore P_{in} = 18490.526 = \sqrt{3}\, V_1\, I_1\, P.f_1$

$\therefore I_1 = \frac{18490.526}{\sqrt{3} * 500 * 0.85} = \boxed{25.1188 \text{ A}}$ # ②

$\therefore \eta\% = \frac{P_{out}}{P_{in}} * 100 = \frac{14920}{18490.526} * 100 = \boxed{80.7\%}$ # ③